SURVEY OF THE GEOLOGY OF HAITI

GUIDE TO THE FIELD EXCURSIONS IN HAITI

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By

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STRATIGRAPHY

Geologic information available to date on Hispaniola gives little evidence to suggest the presence of rocks older than lower Cretaceous or possibly Jurassic. Claims of probable Paleozoic rocks at the island of La Tortue (Sprezniosl o, 1976; in Pierre, 1982), are doubtful at best. So far the oldest dated rocks reported in the literature yielded minimum ages of 123 to 127 m.y. for a metamorphic event that effected the basement complex of the Duarte Formation in the Dominican Republic (Bowin, 1966; Kesler et al., 1977). These absolute dates thus indicate that the metamorphosed rocks of the Duarte Formation must have been deposited at least during Early Cretaceous time, Neocomian stage. Their maximum age is still unknown. Recent structural studies in the northern areas of the Central Cordillera in the Dominican Republic (Draper and Lewis, 1980), further suggested that the Amina schist may be older than the Duarte Formation. These authors also indicated that there are remarkable similarities between the Amina schist and the schists found at the island of La Tortue. This suggestion may therefore support earlier contention concerning the more ancient character of the rocks found at La Tortue relative to other Cretaceous rocks on Hispaniola, but an exact date is still to be determined.

From the geologic evidence at hand there is, however, general consensus that the Central Cordilleran series are the oldest rocks of the Mesozoic-Cenozoic Hispaniolan island-arc system. The Cul-de-Sac/Enriquillo grabben would mark the natural boundary between the recognized northern island-arc system and the Southern Peninsula, which is now considered an uplifted analog of the adjacent Caribbean crust (Maurrasse et al, 1977, 1979a; Maurrasse, 1982c; Sayeed et al., 1978).

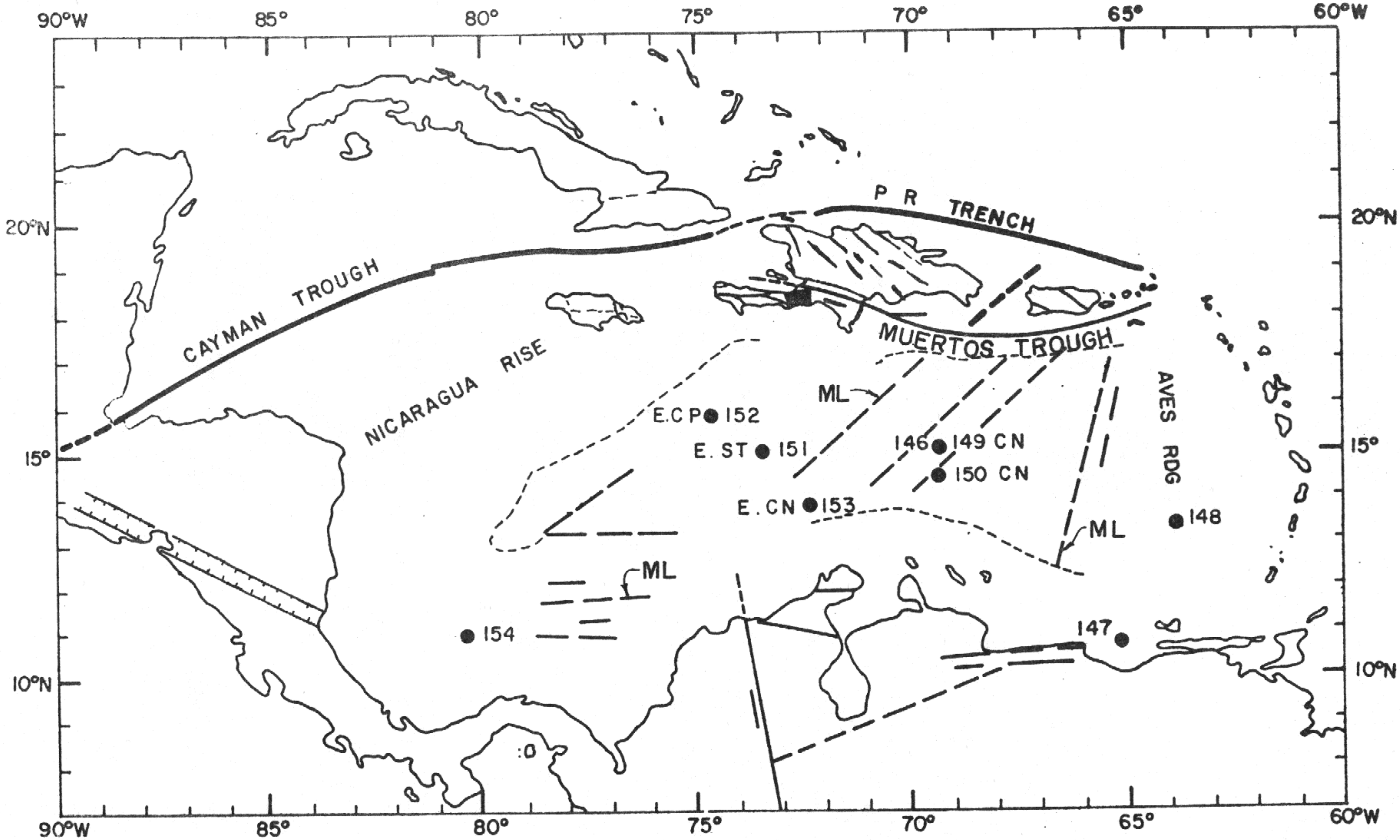
The oldest radiometric dates available for the Southern Peninsula have given a whole rock K/Ar age of 75± 1.5 m.y, Early Campanian to latest Santonian (Sayeed et al., 1978), for a coarse dolerite intruded in the upper part of the Dumisseau Formation (Maurrasse et al., 1979a). The lower part of this formation has also yielded radiolarian taxa which also suggest the presence of the early Late Cretaceous, Turonian stage. Based on the stratigraphic position of the radiometrically dated level, Maurrasse et al, 1979a) further concluded that the lowermost part of the formation may lie within the Early Cretaceous.

Reeside (1947) also described Aptian - Albian Caprinids and Ammonoids from rocks collected by Woodring at a locality northeast of Jacmel. Geochemical data from the Dumisseau rock complex (Maurrasse et al., 1977; Sayeed et al., 1978; Crews, 1978) led to further suggestion that the geotectonic environment of the Cretaceous rocks in the Southern Peninsula was analogous to a back-arc spreading system (Maurrasse, 1982c).

OUTLINE OF THE PRINCIPAL ROCK FORMATIONS OF HAITI

CRETACEOUS - PALEOGENE

TROIS RIVIERES FORMATION: Butterlin, 1954; p. 151. Named After the River "Trois Rivieres" in Northern Haiti.



----- Limit of seismic reflector "Horizon B".

ML Magnetic lineations.

CN CONIACIAN.

E. CN Early CONIACIAN.

E. CP Early CAMPANIAN.

E. ST Early SANTONIAN.

FIGURE 10 - Simplified structural map of the Caribbean region showing limit of occurrence of seimic reflector B", and patterns of magnetic lineations. (Numbers refer to Deep Sea Drilling Project Leg 15 sites)

Type locality: Road Plaisance - Pilate, at 5.1 km west-north-west of the town of Plaisance (Figure 1), in the valley of the Trois Rivieres.

The Trois Rivieres Formation is described to include intercalations of thinnly bedded argillites, brown and gray shales, dark gray to varicolored thickly bedded crystalline limestones with benthic and planktonic foraminifera, occasional rudistids and red or dark-colored radiolarian cherts. Occasional beds of sandstones and conglomerates are also reported to occur in the sequence (Figure 11). The limestone shows extensive calcitic veins related to microfissuration.

Its thickness has been estimated to be no more than 500 meters at the type locality, whereas it is supposed to reach thicknesses of several thousand meters near the border of the Dominican Republic in northeast Haiti (Nicolini, 1977).

Woodring et al., 1924, suggested an Early Cretaceous age for this predominately clastic sequence on the basis of its lithostratigraphic position. According to Butterlin (1960), the formation is in part at least upper Cretaceous, and its topmost levels may lie within the Campanian or even the Maastrichtian. These ages are based on fossil foraminifera.

The Trois Rivieres Formation crops out at several localities in the North of Haiti where it is known at Anse-a-Foleur (on the road from Gros Mornes to Port-de-Paix), in the eastern flanks of the hills adjacent to Cap-Haitian, west and north of Dondon, respectively.

Other unamed rock sequences with clastic facies and of probable Cretaceous age also occur in Northern Haiti, Massif du Nord region (Figures 2, 4). They consist of rhyolitic volcanoclastic and sedimentary deposits, including black shales, volcanogenic breccias, tuffites together with rhyolites, dacites and microgranites. This volcano-sedimentary series is reported to unconformably overly an older ultramafic complex (Nicolini, 1977). Its age has been inferred to be pre-Albian. Similarly, a thick series of polygenic volcanoclastic conglomerates and agglomerates, andesitic lavas of various compositions, red argillites, pisolitic and pseudopisolitic limestones, and limestones with molluscan shell fragments are believed to be probably of Albian age (J. Marie, in Nicolini, 1977). An angular unconformity appears to separate the pre-Albian rocks from the Post-Albian rocks. These rocks apparently continue southeastward into the Central Cordillera in the Dominican Republic. The part composed of pre-Albian black shales has also been suggested to represent the northwestern extension of the gold-hearing uppermost Pueblo Viejo member of the Los Ranchos Formation of Bowin (1966) in the Dominican Republic.

The Los Ranchos Formation has been dated as medial Albian to medial Aptian, based on the presence of the following benthic foraminiferal species: Orbitolina concava texana and Quinqueloculina sp. (Bronnimann, in Bowin 1966). More recent studies of plant fossils found in a lens of black limestone in the Platanal Member underlying the Pueblo Viejo Member also indicate an unspecified Early Cretaceous age for these rocks (C.J. Smiley, written communication, in Field Trip B - Gold deposits of Pueblo Viejo, Rosario Dominicana, S.A.; Field Guide 9th Caribbean Geological Conference, Santo Domingo, p 54).

PERIOD			PLATEAU CENTRAL & MONTAGNES NOIRES	PLAINE DU CUL-DE-SAC	NORTHWESTERN PENINSULA	SOUTHERN PENINSULA
CENOZOIC	RECENT					
CENOZOIC	PLEISTOCENE					
CENOZOIC	PLIOCENE		HINCHE (Jones, 1918): gravels, clays, sandstones LASCAHOBAS(Jones,1918): sandstones, sands, clays, conglomerates, marls, lignite North of Lascahobas	MORNE DELMAS (Butterlin, 1950): conglomerates, clays, marls Road from Lalue to Morne Delmas		RIV. GAUCHE (Butterlin, 1954): sand, clays, calcareous sandstones, conglomerates Old road Fauche - Jacmel
CENOZOIC	MIOCENE	L	MAISSADE (Jones, 1918): clays, marls, sandstone, lignite Valley of Riv. Blanche	RIV. GRISE (Buttlin, 1950): conglomerates, marls, clays Trail to Bassin General; Habitation Cadet; Morne Jacquot		
CENOZOIC	MIOCENE	M	THOMONDE (Jones, 1918): sandstones, conglomerates - claystone Near Thomonde			
CENOZOIC	MIOCENE	E	Mme JOIE (Woodring, 1922): marls, shales, limestones Near Morne Mme. Joie IARC (Kirk, 1940): congl. ls., coraline ls., marls, thinnly bedded ls. CALCAIRE de BASSIN ZIM		LA CRETE (Butterlin, 1954): limestones, sandstones, sand, marls Road from Gonaives to Gros Morne	
CENOZOIC	OLIGOCENE	L				JEREMIE (Maurrasse, 1980): pelagic foraminiferal - nannoplankton chalk with chert stringers and occasional shallow-water calcareous turbidites
CENOZOIC	OLIGOCENE	M				
CENOZOIC	OLIGOCENE	E				
CENOZOIC	EOCENE	L			CALC. de PLAISANCE (Vaughan, 1921) = form. d'ENNERY (Butterlin, 1954) = CRETE SALE (part) (Butterlin, 1957): yellow crystalline limestone, conglomerates with pebbles of cretaceous rocks Road from Plaisance to Ennery-St. Michel de l'Atalaye	
CENOZOIC	EOCENE	M	PERODIN (Butterlin, 1954): congl. volc. tuffs, clays, ls. Between Trail Pte. Montagne - Maissade and Fie Fie - Mme. Joie			
CENOZOIC	EOCENE	E	ABUILLOT [=ABRIO] (Bermudez, 1949): sandstones, sandy shales, shales, limestones Along Riv. Abrio, Plateau Central			MARIGOT (Butterlin, 1954): clays-detrital limestones, conglomerates, sandstones. Trail from Marigot to Morne Lindor-Seguin
CENOZOIC	PALEOCENE					BELOC (Maurrasse, 1980): pelagic ls., chert, basal polyg. conglomerates. Beloc
MESOZOIC	CRETACEOUS	L			TROIS RIVIERES (Butterlin, 1954): clays, shales, claystones, conglomerates, radiolarites. Rd. from Plaisance to Pilate	MACAYA (Butterlin, 1954): clays, marls, shales. Riv. Glace, Rd. Jeremie-Cayes DUMISSEAU (Maurrasse et al, 1979) basals, pillow lavas, pelagic ls. - chert stringers. Dumisseau - N.E. Kenscoff
MESOZOIC	CRETACEOUS	E				

FIGURE 11 - SYNOPSIS OF THE MAIN FORMATIONS IN HAITI.

Thus it is possible that the unamed rocks cropping out in northern Haiti and believed to be of Early Cretaceous age belong in the Los Ranchos Formation.

MACAYA FORMATION: Butterlin, 1954, p. 52, 84. Named aater Pic Macaya in the Massif de la Hotte (Figures 2, 3, 4).

Type locality: Road between Les Cayes and Jérémie, in the valley of Riviere Glace, at 100 meters northeast of the point where the river crosses the road (Figure 12).

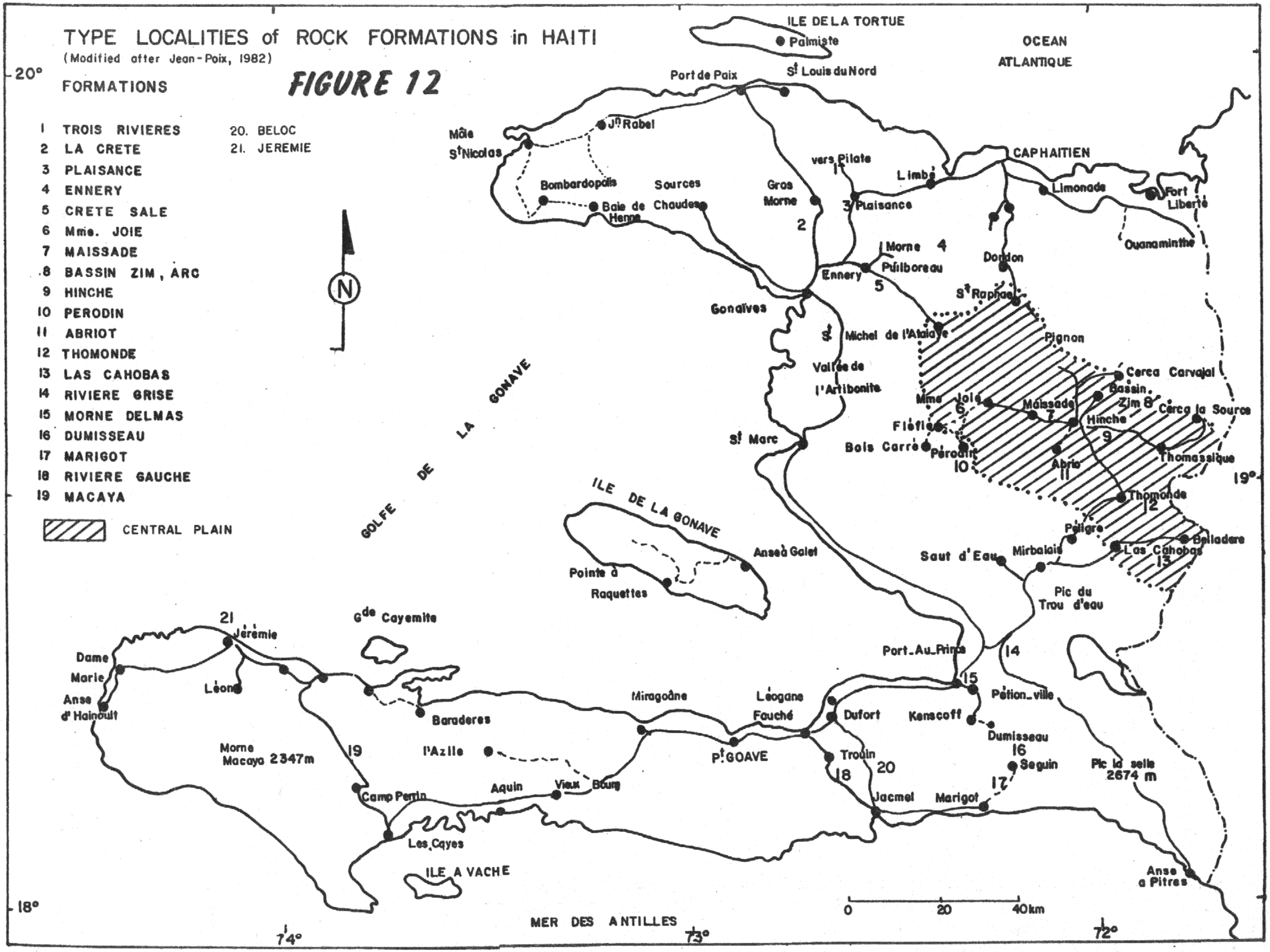
The Macaya Formation comprises a sequence of massive varicolored recrystallized and sparsely silicified limestones with abundant calcite veins. These limestones contain varying amount of clay materials and other impurities which give them different colors, often chocolate brown, green, purplish brown, yellowish gray, or pure white. They are nearly identical to similar lithofacies recovered from drill sites in the adjacent Caribbean Sea during DSDP leg 15 (Edgar et al., 1973; Maurrasse, 1973). The Macaya Formation also includes intermittent argillaceous layers intercalated with the limestones in which the clay content seems to increase toward the base of the series. Occasional radiolarian cherts may also occur as stringers in the limestones (Figure 11).

Butterlin estimated the thickness of the Macaya Formation to be no less than 2000 meters. However, because the Formation is extensively tectonically disturbed, and also because their counterpart in the Venezuela Basin are apparently no thicker than 500 meters, their maximum thickness is expected to be less than a 1000 meters.

As for most of the rock formations found in Haiti, Woodring et al., (1924) were the first to point out the presence of these rock sequences in the Southern Peninsula of Haiti. They assigned an Early Cretaceous age to these rocks. Butterlin (1954) suggested an age of at least upper Maastrichtian for the upper part of the sequence which yielded a planktonic foraminiferal fauna with Globotruncanids, Heterohelicids, and Hedbergellids. The radiolarian fauna in these rocks also suggested a Cretaceous affinity by the presence of Dictyiomitrids. Ayala-Castanares (1969) later assigned a Campanian to Maastrichtian age to these rocks, based on the presence of Globotruncana taxa, characteristic of these stages.

My study of the area of Massanga, northwest of Peak Macaya, further shows that the varicolored limestones of the Macaya Formation may be as old as Santonian. They contain abundant planktonic foraminifera including Globotruncana concavata, Gt. arca, Gt. lapparenti, Gt. falsostuarti, Praeglobotruncana citae. Thus, the Macaya Formation ranges in age from at least the Santonian to the Maastrichtian.

The Macaya Formation crops out essentially in the western regions of the Southern Peninsula of Haiti, west of the Jacmel Fauche depression (Massif de la Hotte). It occurs mostly in the axial regions of the Massif de la Hotte at large, and is underlain by deformed rocks of the Dumisseau Formation (Maurrasse et al., 1979a).


TYPE LOCALITIES of ROCK FORMATIONS in HAITI
(Modified after Jean-Poix, 1982)
FIGURE 12
FORMATIONS
1 TROIS RIVIERES
2 LA CRETE
3 PLAISANCE
4 ENNERY
5 CRETE SALE
6 Mne. JOIE
7 MAISSADE
8 BASSIN ZIM, ARC
9 HINCHE
10 PERODIN
11 ABRIOT
12 THOMONDE
13 LAS CAHOBAS
14 RIVIERE GRISE
15 MORNE DELMAS
16 DUMISSEAU
17 MARIGOT
18 RIVIERE GAUCHE
19 MACAYA
20. BELOC
21. JEREMIE
CENTRAL PLAIN
N
20°
19°
18°
74°
73°
72°
ILE DE LA TORTUE
Palmiste
St Louis du Nord
Port de Paix
OCEAN ATLANTIQUE
Môle St Nicolas
Jn Rabel
Bombardopolis
Baie de Henne
Sources Chaudes
Gros Morne
vers Pilate
Plaisance
Limbé
CAPHAITIEN
Limonade
Fort Liberté
Ouanaminthe
Dondon
Morne
Puilboreau
Ennery
St Raphael
Gonaïves
St Michel de l'Atalaye
Pignon
Vallée de l'Artibonite
Cerca Carvajal
Bassin Zim
Cerca la Source
Mme Joie
Maïssade
Hinche
Fiéfié
Bois Carré
Perodin
Abrio
Thomassique
St Marc
Thomonde
GOLFE DE LA GONAVE
ILE DE LA GONAVE
Anse à Galet
Pointe à Raquettes
Péligre
Belladere
Las Cahobas
Saut d'Eau
Mirbalais
Pic du Trou d'eau
Gde Cayemite
Jérémie
Dame Marie
Anse d'Hainault
Léon
Baraderes
Miragoâne
Léogane
Fauché
Dufort
Kenscoff
Port_Au_Prince
Pétion_ville
Dumisseau
Morne Macaya 2347m
l'Azile
P.t GOAVE
Trouin
Seguin
Pic la selle 2674 m
Camp Perrin
Aquin
Vieux Bourg
Jacmel
Marigot
Les Cayes
ILE A VACHE
Anse a Pitres
MER DES ANTILLES
0 20 40km

DUMISSEAU FORMATION: Maurrasse et al., 1979a, p. 71, 83. Named after the hamlet of Dumisseau, southeast of Kenscoff, in the Massif de la Selle (Figures 8, 12).

Type locality: Hills of Dumisseau, east and west of the Saint Dominique Church, at Haiti meter grid 792,500 mE; 2,038,500 mN, and 791,300 mE; 2,039,300 mN to 2,038,700 mN respectively.

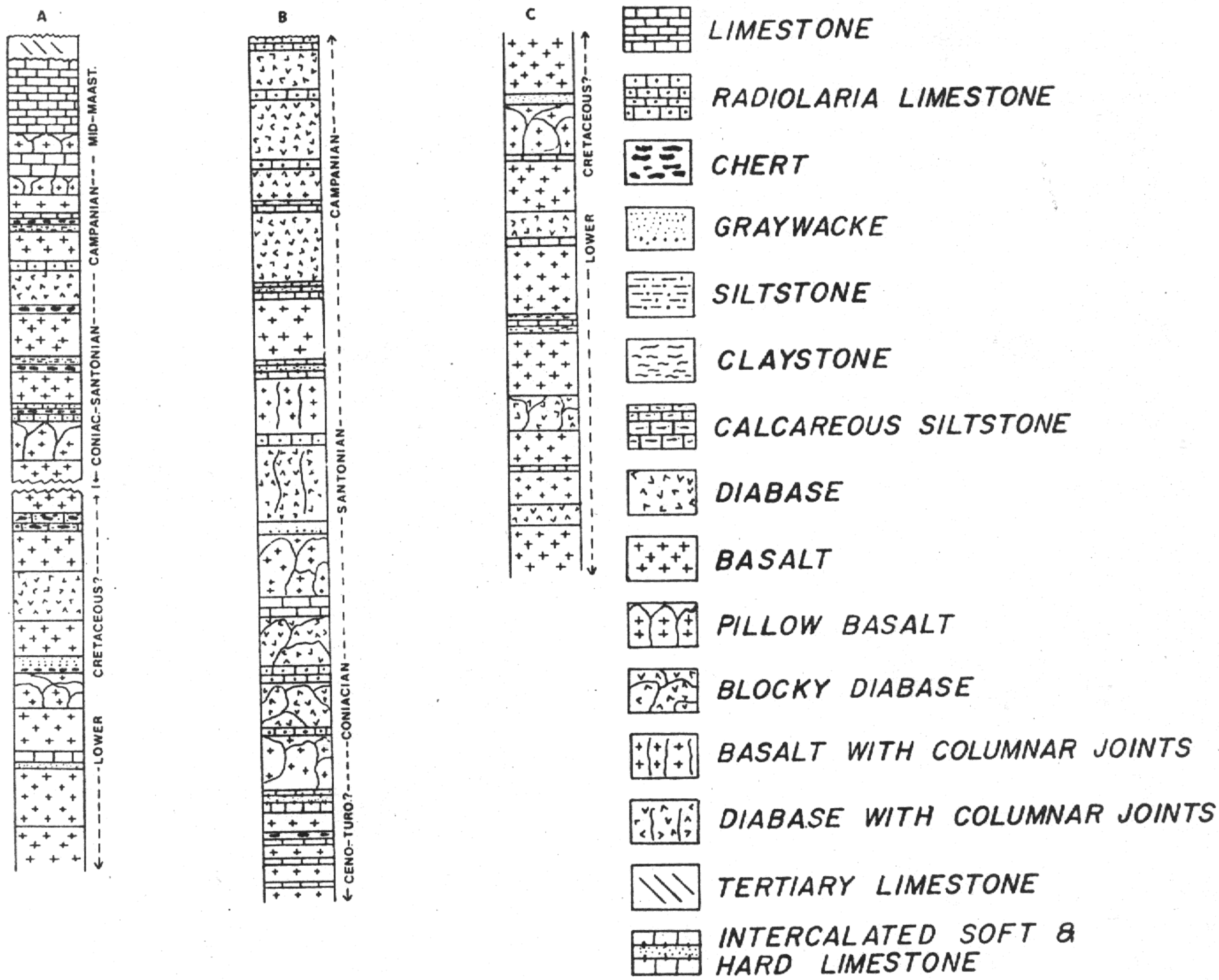
The Dumisseau Formation includes the upper Saint Dominique Member and a lower unamed Member. The formation as a whole is essentially characterized by a sequence of interbedded pillowed and non-pillowed basalts, dolerites, pelagic limestones, intrabasinal volcanogenic turbidites, varicolored cherts and siliceous silstones (Figure 11). The sequence becomes more calcareous toward the top. Although shallow-water limestones including Caprinids and Ammonoids have been reported from a locality north of Jacmel (Reeside, 1947), no shallow-water facies has been found at the type locality. The uppermost part of the Saint Dominique Member consists predominately of grayish orange (10YR7/4) to yellowish gray (5Y7/2) limestones and chalks, varying also to medium gray (N5) and medium olive gray (5 Y 5/1). Silicification pervades all the calcareous beds, although true chert stringers are rare in the topmost thirty meters or so of the exposed sequence at Dumisseau. Most of the calcareous layers can be described microscopically as sparse fossiliferous micrites, but occasional beds are truly packed foraminiferal-radiolarian micrites. These grain-supported layers usually display a sandy texture and slighly graded bedding, much in the same manner as similar layers described in the pelagic limestones recovered at DSDP Leg 15, Site 146/149 (Figure 10) in the Venezuela Basin (Maurrasse, 1973, Schneiderman, 1973).

The sedimentary layers of the lower Member are mainly greywacke with graded bedding and cross laminations, shales, silstones, and occasional claystones of intrabasinal volcanogenic origin. Chert stringers usually show gradation from dispersive and selective silicification of allochems to pervasive silicification of the matrix in the calcareous layers. Chertification is thus a progressive replacement of the calcareous constituents by microcrystalline quartz (Maurrasse et al., 1979a). Cherts of the Dumisseau Formation are also much the same as those recovered at different levels in the pelagic sequences of the Caribbean Sea (DSDP, Leg 15, op. cit.), particularly those found at Sites 146/149, 152, 153 (Figure 10).

The igneous rocks range in grain size from microcrystalline to doleritic in dikes and sills that transect, or are concordant with the sequence. Occasional gabbroic intrusions occur interspersed in the formation, while lherzolite may occur in limited expanse toward the base of the Lower Member. The dolerites, like the basalts, exhibit glomeroporphyritic, ophitic and intergranular textures. Groundmass in these rocks is composed essentially of clinopyroxenes, olivine and opaques. Some dolerites also display characteristic variolitic structure in which the plagioclase phenocrysts are radially arranged, diverging from a common center, and all immersed in the ground mass of mafic minerals. A given diabasic unit may show variolitic structure near the contact zone with the adjacent unit, while its interior portions have intergranular and intersertal textures. The gabbros and lherzolites show primary cumulate textures with cumulate of olivine and

FIGURE 13

Composite Section of the Dumisseau Formation



Schematic lithologic representation (not to scale) of sequences at A: St. Dominique ridge; discontinuity in the column does not correspond to an unconformity but rather stresses the composite character of the sequence described at this ridge. B: hill east of St. Dominique; C: the section of the lower member exposed at Ravine Nan Roseau

(From Maurrasse et al., 1979)

clinopyroxene, and intercumulus plagioclase (Maurrasse et al., 1977; 1979a).

The geochemical characteristic of the igneous rocks point to their abyssal tholeiitic affinities (Maurrasse et al., 1979a).

Woodring et al. (1924), were also the first to notice the presence of sedimentary layers and cherts in the igneous complex of the Southern Peninsula. They assigned a Late Cretaceous age to these rocks. As pointed out earlier, recent studies of these rocks indicate that the maximum age of the formation lies probably within the late Early Cretaceous, or early Late Cretaceous Turonian stage. The lower member has indeed yielded probable Heterochelicids, and taxa of the families Planomalinidae (_Globigerinelloides_ sp.) and Rotaliporidae (_Hebergella_ spp, _Rotalipora_ spp.), indicative of an Early Cretaceous age. Furthermore, the radiolarian fauna in these rocks include species such as _Crucella_ cf. _cachensis_, _Crucella_ sp. (affinity _Crucella_ sp., Foreman, 1973, Pl. 13, figures 18, 19), and _Haliodictya_ aff. _hojnosi_ which indicates age ranging from the Early Cretaceous to the early Late Cretaceous, Turonian stage. The lower part of the Saint Dominique Member lies within the Cenomanian, or possibly within latest Early Cretaceous, as suggest the foraminiferal fauna which includes _Hedbergella planispira_, _H. amabilis_, _Praeglobotruncana_ spp., _Ticinella roberti_, and Radiolaria of the _Stichomitra asymbatos_ group.

The thickness of the Dumisseau Formation as estimated in the type area is reported to exceed 1.5 kilometers (Maurrasse, et al, 1979a). Outcrops of this formation occur along most of the axial region of the entire Southern Peninsula. Post depositional, and synformational deformations within the formation can be seen to increase westward in the Peninsula. In some areas, intense deformation led to a tectonic melange (Coleman, 1977). Such an example can be seen along the road from Carrefour Dufort to Jacmel (figure 9).

Relationship between the Dumisseau Formation and the Caribbean Sea Crust

Until the results from drilling in the Caribbean Sea (Edgar et al., 1973), most interpretations of the composition of the Caribbean crust relied essentially on seismic reflection and refraction surveys (Officer et al., 1959; Ewing et al., 1960; 1967; Edgar et al., 1971), and spot samples recovered by the Ewing piston coring method (Ewing et al., 1965). The seismic surveys recognized the existence of a smooth acoustic basement underneath normal acoustically transparent sediments in the Caribbean Sea. This reflector was equated to similar acoustic features in the Pacific and the Atlantic Oceans termed Horizon B and Horizon B′, respectively; hence, the Caribbean reflector was named B". Weaker reflectors detected underneath the Caribbean B" reflector, were thus designated sub-B" reflectors. By the same analogy, a shallower reflector which occurs in the pelagic sediments above the B" horizon marker, was named A". Samples from exposed outcrop of A" at the Beata Escarpment, on the west side of the Beata Ridge, were analysed prior to the Deep Sea Drilling expedition in the area, and were found to correspond to a silicified level of a radiolarian limestone. Thus the A" horizon could be correlated with the presence of cherts at this level.

The Deep Sea drilling results corroborated the previous finding, as A" was actually due to the impedance contrast between the softer non-silicified pelagic sediments and the harder chert layers, which appear nearly consistently in medial Eocene sediments. Average sound velocity in sediments above A" was found to be 1.63 Km/sec, whereas average sound velocity in the interval between A" and B" is 2.5 to 2.6 Km/sec, with values as low as 1.9 Km/sec. In contrast to these low-velocity materials, sound velocity in the cherts may be as high as 5.67 km/sec (Boyce, 1973). Rocks comparable to the A" horizon also occur above the Dumisseau Formation.

The drilling results also showed that Horizon B" could be correlated with tholeiitic basalts and doleritic sills intercalated with, and overlain by pelagic sediments of Coniacian to Campanian ages (Edgar et al, 1973). The crust below B" was unfortunately not reached. The uncertainty concerning the exact nature of the sub-B" reflectors thus remained unsolved. The reflectors were generally suggested to be composed of intercalated igneous and sedimentary rocks (Edgar et al., 1971; Hopkins, 1973; Ludwig et al., 1975; Case, 1975; Matthews and Holcombe, 1976; Ladd and Watkins, 1977).

The possible relationship between the complex sedimentary and igneous rocks of Cretaceous age in the Southern Peninsula and those in the Caribbean Sea became meaningful as a result of the writer's participation in DSDP Leg 15. It was during this expedition that remarkable similarities between the deep-sea materials and those previously observed at the Southern Peninsula were noted. Subsequent onshore studies of the Caribbean Sea materials, and field and laboratory analyses of the Southern Peninsula rocks further Substantiated this initial inference (Edgar et al., 1973; Maurrasse, 1976, Maurrasse et al., 1977; 1979a). Further lithologic sutdies, and paleomagnetic analyses of these rocks (Kent and Maurrasse, 1982), also corroborate the analogy. Recent multichannel seismic studies in the Caribbean Sea (Diebold et al., 1981; Stoffa et al., 1981; have also brought corroborative evidence to the effect that the seismic character of the Caribbean crust below acoustic reflector B" is in agreement with the lithologic sequence observed in the Dumisseau Formation.

The Dumisseau Formation, therefore, provides an exceptional opportunity to analyze a land analog of the elusive sub-B" reflectors. As pointed out hereinbefore, because the geologic data at hand supports the analogy, the Dumisseau Formation is considered to represent materials analogous to those of the adjacent Caribbean crust. These rocks thus show evidence that the Southern Peninsular is a portion of the Caribbean crust uplifted through differential vertical motion taking place along the northern boundary of the Caribbean megashear. Dismembered limestone and chert layers in the igneous matrix indicate that the structures were formed as a result of increased polyphase deformation from initially ductile to more brittle in late stages. Deformation is more intense westward as these areas were closer to the accretionary prism of the Nicaragua Rise-Jamaica subduction Zone (Maurrasse, 1982c).

<u>BELOC FORMATION:</u> Maurrasse, 1980a, p.25; 1982a, p.184,188. Named after the village of Beloc located immediately north of the formation (fig.12).

<u>Type locality:</u> Mountains South of Beloc, at the westernmost end of the Massif de la Selle, at Haiti meter grid 755,600 mE; 2,031,750 mN; close to an altitude of 800 meters on the

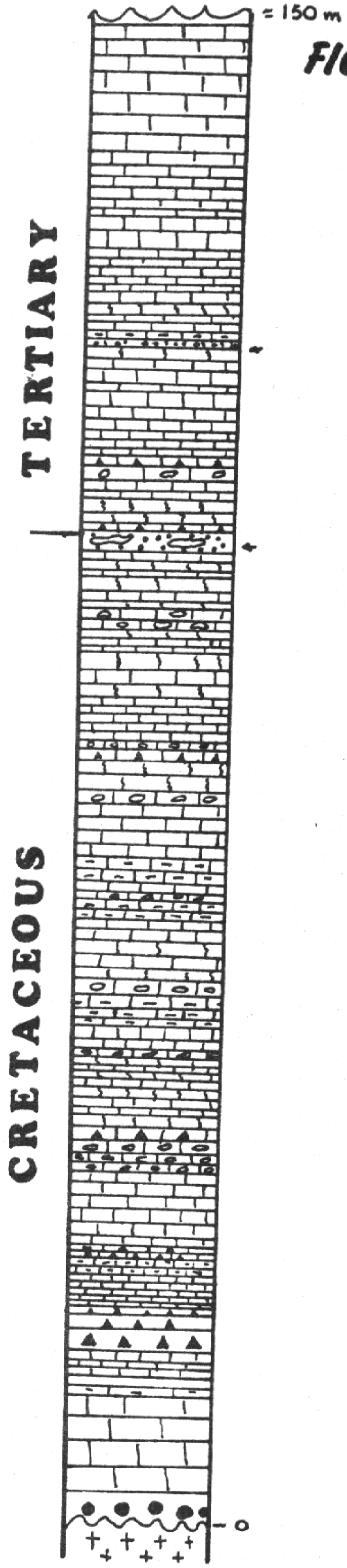
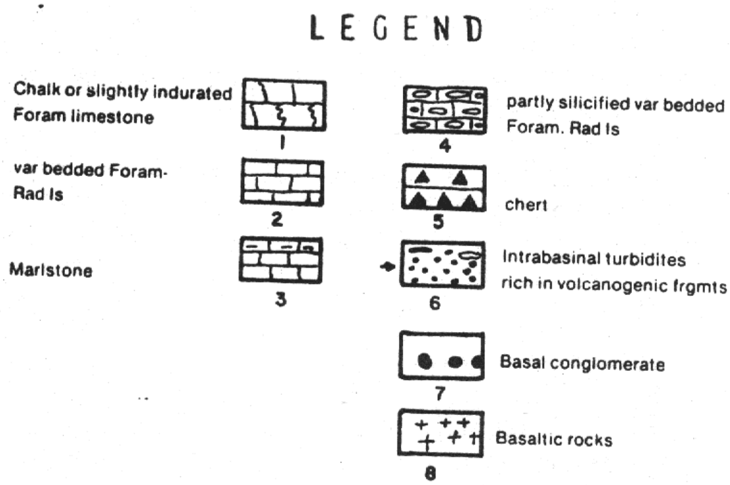


FIGURE 14 : Composite section of the Béloc Formation
(Not to scale)

Middle and upper parts of the section crop out along road cuts as shown in Fig.1 Lower part of the section can be found only in deep gullies and stream beds at topographic levels below road cuts.

(From Maurrasse, 1982a)



mountain road from Carrefour Dufort to
Jacmel, and 4 to 5 kilometers south of
the village of Beloc (Figures 2,4,14,15).

Rocks typical of the Beloc Formation include a monogenic basaltic basal conglomerate about 1 to 2 meter thick overlying weathered igneous rocks of the Dumisseau Formation. The conglomerate intergrades with the weathered igneous rocks, and the overlying sequence consists essentially of homogenous pelagic limestones and chalk interbeds. The calcareous rocks are typically very light tan to grayish white color when they are dry, but turn into much darker hues (brownish gray) when wet (Figure 11).

The beds in the lower part of the sequence vary from about 3 cm to 100 cm in thickness, those in the upper part are thinner (Figure 15). Bedding is often only apparent, and is related to differential diagenetic lithification rather than true compositional differences, although there may be minor ones. Similar lithologic characteristics were also found in upper Cretaceous sediments of the Caribbean Sea (Maurrasse, 1973). Despite the apparent lithologic homogeneity of the sequence, several synformational sedimentological disturbances occur at different intervals. The most conspicuous such level occurs about 40 to 50 meters from the base of the series at the type section. It consists of a 50cm thick volcanogenic turbidite showing typical subaqueous flow structures. This turbidite is overlain by a 2 cm thick marl believed to delimit the Cretaceous and the Tertiary (Maurrasse et al., 1979b). Two lesser (less than 2 cm thick) intrabasinal volcanogenic turbidity flow deposits also occur above the main marker bed. Less conspicuous in the limestone sequence are occasional intraformational conglomerates which become visible only on weathered surfaces of the exposed rock. Secondary structures are essentially those related to series of parallel gravity faults and shearing in the rocks during tectonic deformation (Figure 15).

Microscopically, the limestones consist of sparse micrites with variable amount of Radiolaria. Silicification is predominately dispersive, and becomes pervasive only at certain levels within the latest Maastrichtian. Chert stringers are usually very dark brownish gray to dark gray. Again the analogy with cherts recovered at similar stratigraphic level in the Caribbean Sea (Maurrasse, 1973) is most striking.

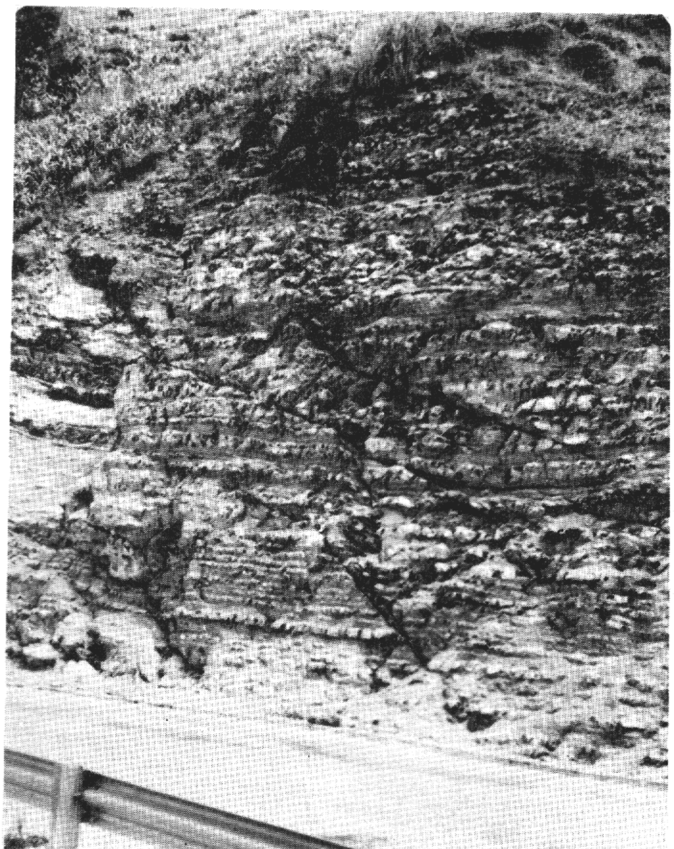
The age of the Beloc Formation ranges from the Late Maastrichtian <u>Globotruncana contusa</u> Zone to the earliest Paleocene, Danian stage, possible the <u>Globorotalia pseudobulloides</u> Zone. The maximum thickness of the formation at the type section is about 150 meters. Its lower boundary lies uncorformably over rocks of the Dumisseau Formation, and its upper limit is undetermined. Although its lower limit is Late Cretaceous at the type section, outcrops of Campanian and older Maastrichtian rocks immediately north of the Village of Beloc suggest that the lower boundary of the Beloc Formation may be diachronous. It may, therefore, be older than Maastrichtian in certain areas, or even intergrade with the uppermost part of the Dumisseau Formation.

FIGURE 15

BELOC FORMATION (TYPE LOCALITY)

a

b



Problems associated with the Cretaceous/Tertiary boundary in the Beloc Formation.

As I pointed out in the preceding paragraph, the lithologic sequence of the Beloc Formation includes a major marker bed which consists of an intrabasinal turbidity deposit. It has been found (Maurrasse et al., 1979b), that the 2cm-thick marl overlying it includes a foraminiferal assemblage attributable to the earliest Danian stage, Globigerina eugubina Zone. Typical Danian fauna such as Globigerina eugubina and Globigerina fringa become conspicuously abundant at that level whereas their presence is either doubtful or the assemblages are so rich in uppermost Cretaceous taxa that the underlying levels can not positively be assigned to the Danian. Despite the fact that the marl layer contains enough of the Danian taxa to warrant its being placed in the Tertiary, it also includes numerous Cretaceous species which are apparently not reworked from older levels (Maurrasse, 1982a). The earliest Tertiary seems to be characterized by a mixture of surviving Cretaceous taxa together with a dominance of the triserial taxon here assigned to Gumbelitria cretacea. This taxon is so characteristic of this elusive Cretaceous/Tertiary transition zone at Beloc that it is suggested that the uppermost level of the Maastrichtian and the lowmost Danian stage could be identified as the Gumbelitria cretacea Zone.

The nannoplankton flora also give conflicting evidence concerning the Cretaceous/Tertiary boundary at Beloc. Perch- Nielsen (Written communication, 1981) pointed out that "most of the forms normally present in higher numbers in NP_1 (very small Biscutum in low latitudes, M. inversus, large Biscutum, and Cyclagelosphaera and P. sigmoides in higher latitudes) here occur only in very low numbers or not at all. On the other hand, there are plenty of Maastrichtian forms and obviously some reworked forms that normally disappear near the Campanian/Maastrichtian". The only criterion which may be used to indicate the passage into the Danian is the abundance of Thorocasphaera. Perch-Nielsen (op. cit.) further indicates that Thoracosphaera is very rare in the samples below the assigned boundary, whereas it becomes rare to few above, and suggests" thus one can assume that these samples can be correlated with samples from other sections in NP_1".

Thus, both the foraminifera and the nannoplanktons indicate degrees of reworking which are somewhat compatible with the sedimentary distrubances observed at this level assigned to the Cretaceous/Tertiary boundary. The absence of certain typical nannoplankton taxa, and the occurrence of supposedly Cretaceous foraminiferal taxa within the assigned Danian remain a puzzle, although the evidence at hand suggests that the Cretaceous Tertiary organisms truly overlapped.

Assuming that an Iridium high is everywhere contemporaneous at the Cretaceous/Tertiary boundary, as it has been proponed in the literature, a similar occurrence in the marl above the volcanogenic marker bed at Beloc is surely the most convincing argument for this level being the boundary (Alvarez et al., 1982). Yet, again some difficulties arise because appreciable Iridium anomaly also occurs in a marl lens within the volcanogenic turbidite below the marl layer (Asaro, oral communication, February, 1982). This peculiarity also remains to be explained.

The volcanogenic bed appears to have come from igneous terranes now lying north of Beloc where the more proximal part of the turbidite contains a larger proportion of older fauna (particularly Campanian fauna) which are reworked from a pelagic chalk. The distribution pattern of the volcanogenic marker bed suggests that it may in fact overlie Cretaceous levels of different ages because of the scouring effects of the turbide flow. Thus, only the distal part of the turbidite lies in a continuous record with the uppermost Maastrichtian and the lowest Danian.

Furthermore, the Beloc Formation which includes a continuous section from Cretaceous to Tertiary also brings evidence in support of early contention (Maurrasse, 1976; Maurrasse et al., 1977; 1978; 1979a) that the major tectonic event in the Southern Peninsula was possibly Pre-Campanian, or early Campanian. These observations are also consistent with unconformities reported in the Dominican Republic (Bowin, 1966). Although large parts of the proto-Hispaniola island arc and its back-arc basin (the site of the future Southern Peninsula) were affected by extensive deformation about Campanian time, emergence must have been limited to certain areas because of block faulting tectonism which has been the dominant tectonic style along this northern edge of the Caribbean plate. It should also be emphasized that a major disturbance does not necessarily imply emergence (even though independent blocks could have come very close to the surface of even been emergent) as attests the pelagic sequence at Beloc.

MARIGOT FORMATION: Butterlin, 1954, p. 57; 106. Named after the village of Marigot, at the southern side of the Massif de la Selle (Figure 12).

Type locality: Northeast of the village of Marigot on the road from Marigot to Seguin.

The lithologic sequence of the Marigot Formation is characterized by the predominance of terrigenous materials of basaltic origin which occur in the different lithofacies of the series. The formation includes varying beds of conglomerates, sandy shales, calcareous sandstones, and clastic limestones (Figure 11). Thicknesses of the different beds usually vary from about 3 cm to 10 cm, with maximum values found in the conglomeratic and limestone beds. The base of the sequence is usually hidden by slope wash, or overlies rocks of the Dumisseau Formation.

The upper part of the formation may intergrade either with very light colored (light yellowish gray to nearly white) lower Eocene biocalcarenites, biocalcirudites, or white thinly bedded white chalky limestones. The coarser limestone facies are rich in benthic foraminifera whereas the chalky facies are rich in planktonic foraminifera. Initially Butterlin (1954) estimated the total thickness of the sequence to be within the range of 900 to 1000 m., but subsequently (1960), he suggested several thousand meters instead. The initial estimates are closer to the real thickness.

The age of the Marigot Formation varies between Paleocene and Early Eocene. The formation is overlain by limestones similar to the lithofacies described as the Neiba Formation (Dohm in Bermudez, 1949, p.21) in the Dominican Republic, and in other cases by the limestone facies of the Plaisance Formation (Vaughan 1921, p. 64).

The Marigot Formation is found in the southern areas of the Massif de la Selle only. Other rock outcrops assigned to this Formation (Butterlin, 1954, 1960) are talus slope breccias at the base of the major fault scarps (Maurrasse et al., 1979a) of the La Selle Fault System.

ABUILLOT FORMATION: Bermudez, 1949, p.19. Named after River Abrio at the southern edge of the Plateau Central in Haiti (Figure 12). Bermudez gave the name of the formation based on field notes of Atlantic Refining Company geologists who mispelled the name of the river.

Type locality: 15 km southwest of Hinche along the valley of river Abrio where it transects the northeastern foothills of the Montagnes Noires (Figure 2,4).

The Abuillot Formation consists of series of brown sandstones, sandy shales, shales and limestones (Figure 11). The base of the formation is marked by a nonconformity with older volcanics, and is apparently conformably overlain by upper Eocene limestones. Its total thickness could be up to a thousand meters as determined from bore holes by the Atlantic Refining Company.

Bermudez (1949) listed the following species as typical of the formation: Alabamina haitiensis, Anomalina abuillotensis, Bathysiphon abuillotensis, Bolivina capdevilensis, Bulimina quadrata, Clavulinoides excurrens, Coleites abuillotensis, Dorothia principis, Globorotalia aragonensis, Gonatosphaera principis, Loxostomum applinae, and Stichocibicides aricki. He suggested an early Eocene age for the formation. Actually the presence of Globorotalia aragonensis indicates an age of late Early Eocene to Middle Eocene.

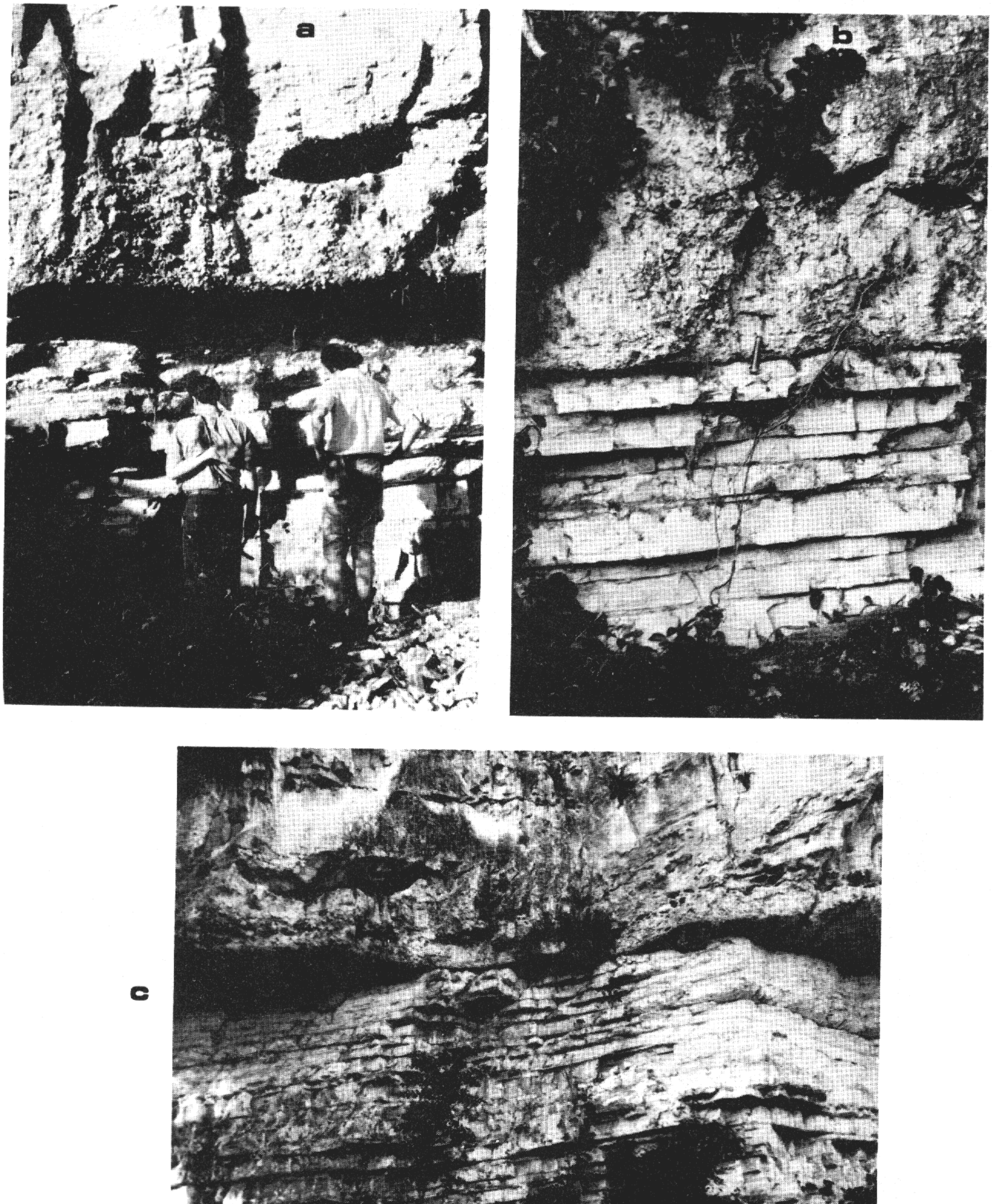
Facies of the Abuillot Formation crop out in numerous areas of the island north of the Cul-de-Sac/Enriquillo graben, and particularly in the Montagnes Noires.

PERODIN FORMATION: Butterlin, 1954, p.433. Named after the village of the same name in the central areas of northwestern Montagnes Noires (Figures 2,4,12).

Type Locality: Perodin and surrounding areas at the highest elevations in the Montagnes Noires.

The lithologic sequence of the Perodin Formation consists of a thick basaltic and andesitic tuff series intercalated with varicolored marls,

FIGURE 16



Shallow-water materials deposited as turbidites in deep-water facies near Ennery.

shales, brown and gray limestones with chert stringers (Figure 11). The series of sandy shales, occasionally interstratified with sandstones and argillites rich in volcaniclastics have also been suggested by Butterlin (1960) to be the possible analogs of similar series in the Abuillot Formation (cf, preceding paragraph). Butterlin indicated that the upper part of the formation is conformably overlain by medial and upper Eocene limestones, while the bottom part of the formation may intergrade with the Abuillot Formation. He also pointed out that the Perodin Formation in the type area shows fault contact with rocks believed to be Oligo-Miocene (limestones of the Madame Joie Formation type of lithofacies, as will be described in subsequent paragraphs).

Butterlin assigned a Middle Eocene age to the Perodin Formation on the basis of the occurrence of benthic foraminiferal taxa such as Euconuloides wellsi (his locality HPS 54-55). Subsequently, Butterlin (1960) also figured younger benthonic foraminiferal taxa which he reported from samples of the Perodin Formation. These taxa include, among others: Heterostegina antillea (his locality HPS 35), Spiroclypeus bullbrooki (his locality HPS 35), Lepidocyclina canelli (his locality HPS 35) and Miogypsina antillea (his 35 locality HPS 56) all reported to indicate an Oligo-Miocene age. Unless these samples were mislabelled and came instead from the adjacent lithofacies of the Madame Joie Formation, the Perodin Formation could be as young as Middle Miocene.

Facies typical of the Perodin Formation crop out over an area about 10 kilometers wide in northwestern Montagnes Noires along the trail going from Petite-Montagne/Maissade to the east, to Bois-Carre-Fiéfié/Madame Joie to the west. The thickness is estimated to be no less than 1000 meters (Butterlin, 1960).

PLAISANCE FORMATION: Vaughan, 1921, p. 64. Named after the town of Plaisance at the foothills of the northern flank of Morne Puilboreau in the Massif du Nord (Figure 12).

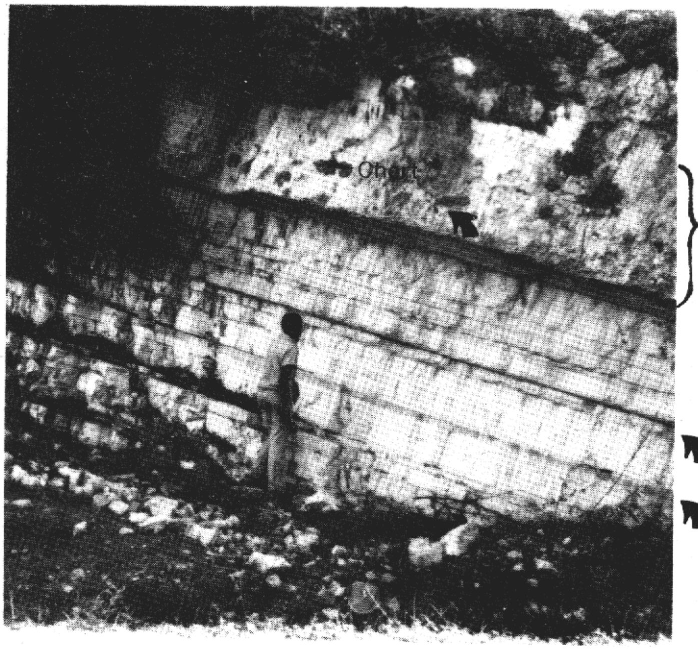
Type locality: On the road between Plaisance and Ennery at an altitude of 705 meters.

The plaisance type of lithofacies, as assigned by Vaughan, consists predominately of thickly bedded biocalcarenites, mainly very pale yellowish brown (10 YR 7/2) to a light pinkish brown (between light brown - 5 YR 6/4, and pale yellowish brown -10 YR 6/2). The basal beds consist of medium coarse conglomerate composed of rounded igneous pebbles and argillite interbedded with shaly material, and with lenses of impure brownish-yellow limestone, which also contains detrital fragments (Woodring et al., 1924, p. 102). Its thickness has not been determined, but is probably less than 500 meters.

As pointed out by Woodring et al., 1924, the Plaisance limestones facies is remarkably rich in benthonic foraminifera of the species Dictyoconus puilboreauensis and Dictyoconus codon. These limestones are also rich in Echinoid, and Pelecypod shell fragments. The age of the formation is Middle Eocene.

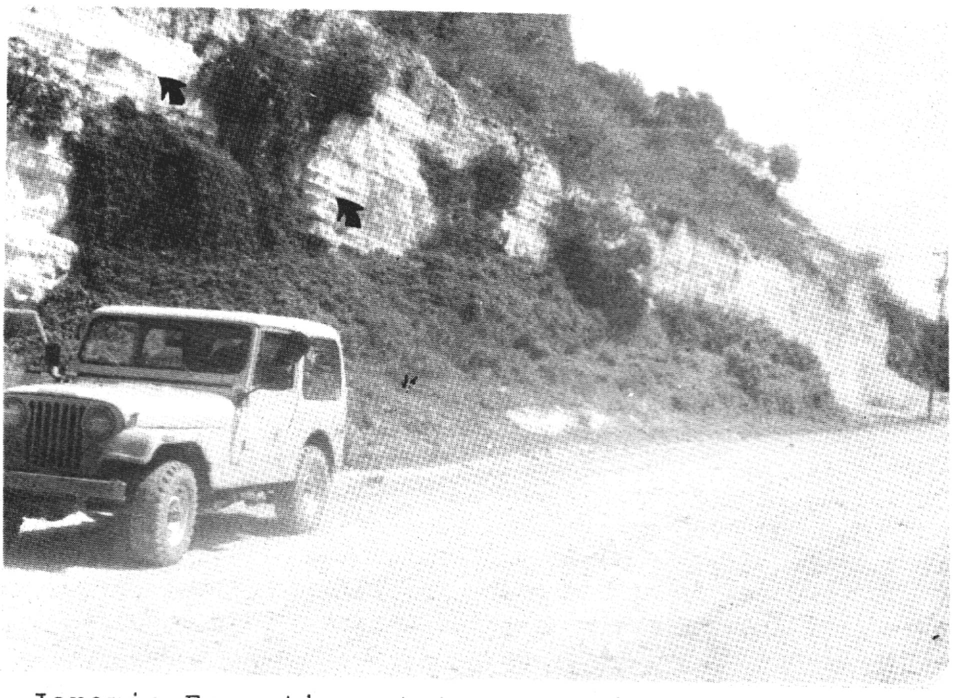
FIGURE 17

A



Turbidites of shallow-water materials, from typical Plaisance Formation limestone, in deeper water equivalent. Near Ennery. Arrows point to thinner silicified turbidites, and chert stringers.

B



Jeremie Formation at type section. Entrance of city of Jeremie.

The Plaisance limestone facies is very widespread over the island of Hispaniola, and it represents a typical shallow- bank deposit. This facies forms most of the prominent mountain ridges and crests in the island.

I also incorporate with the Plaisance Formation the Crete Sale Formation (Butterlin, 1957), and part of the Ennery Formation (Butterlin, 1954) on the sourthern flanks of Morne Puilboreau and adjacent hills, which intergrade with the typical Plaisance limestone facies. The main facies of the assigned Ennery Formation of Butterlin can be correlated with similar facies described as the Neiba Formation in the Dominican Republic (Dohm, in Bermudez, 1949, p.21). These limestones occuring at the southern foothills of Morne Puilboreau are typically thinnly bedded (Figures 15,17a) and include intermittent turbidites composed of materials of the shallower-water Plaisance lithofacies. Thus, the lithofacies near Ennery are here equated to the Neiba type of lithofacies collateral of the lithofacies characteristic of the Plaisance Formation. The latter apparently developed on paleobank systems which came to existence concomittantly with the tectonic dislocation of the island arc in Early Paleogene. Such banks developed south of the Cul-de-Sac graben as well. The back-arc basin also became dislocated due to progressive deformation along the northern boundary of the Caribbean plate. The shallow-water limestones which developed over these banks at different times within the Paleogene, now constitute the dominant relief of most of the physiographic units of high topography described hereinbefore. In the Massif du Nord (figure 2) the deeper-water facies occur southward and southeastward of the Plaisance facies which developed over igneous rocks basement forming the present backbone of this mountain chain.

<u>JEREMIE FORMATION:</u> Maurrasse, 1980, p.26; 1982, p.184,195. Named after the city of Jérémie on the northwest coast of the Southern Peninsula (Figure 12 and 17B).

<u>Type locality:</u> Entrance of the city of Jérémie (Figure 16B). A hypostratotype occurs between 7 and 10 kilometers from Marché Léon, south-southeast of Jérémie.

At the type locality and the hypostratotype, the Jérémie Formation consists predominately of nannoplankton-foraminiferal chalk with very sparse Radiolaria. The chalk is essentially white to very slightly pinkish (Figure 11). Thin silicified layers (2 - 12 cm thick), which often occur as light brown cherts, are intercalated at variable intervals in the chalk layers (Figure 17B). Silicification at these levels is gradational and pervades the chalk adjacent to the chert stringers.

There are no apparent primary structures in the chalks. Secondary sedimentary structures are primary related to minor dislocation caused by normal faults which affect most of the sequence at the type section.

At the type locality there are no apparent stratigraphic boundaries as the formation is overlain by slope wash, and its lower part dips gently below the level of the road (Figure 17B). Nonetheless, in the hills southeast of Jérémie the formation is unconformably overlain by coral rocks of probably

FIGURE 18 : Map showing known outcrops of the Béloc Formation and Jérémie Formation in western Hispaniola (From Maurrasse, 1982a).

Pleistocene age. The age of the Jérémie formation is determined on the basis of a well diversified planktonic foraminiferal fauna which includes among others: Globorotalia siakensis, Gl. opima nana, Globigerina ciperoensis aff. angustiumbilicata, G. ampliapertura, G. venezuelana, G. tripartita, G. rohri, Globorotaloides suteri, Catapsydrax unicavus, and Chilogumbelina cubensis, indicative of a Late Oligocene age. The sequence at the type locality is inferred to range in age from late Middle Oligocene to early Late Oligocene. Also, because medial Eocene eupelagic facies occur farther south in the Southern Peninsula near Jérémie, it is inferred that the base of the Jérémie Formation may lie within the upper Eocene pelagic limestone series of this region.

Facies attributable to the Jérémie Formation also occur in the Northwestern Peninsula (Figure 18), on the road from Bombardopolis to Baie-de-Henne, and on the road Jean-Rabel to Anse Rouge. At these locations, facies of the Jérémie Formation yielded foraminiferal fauna indicative ages ranging from at least Early Eocene (Globorotalia aragonensis Zone), to the Early Oligocene (Hastigerina micra Zone). The same facies occurs in great abundance at the eastern end of the La Selle-Baoruco block, notably south of Thiotte, and beneath the coral cap south of Oviedo (Figure 18). In these areas it is also of Oligocene age and possibly reaches the Early Miocene Globigerinoides primordius Zone. Limited outcrops of this facies also occur south of Beloc, and farther west near the city of Miragoane, on the road to Paillant (Bauxite mining area of the Plateau de Rochelois)(Figure 18). In the latter area the Jérémie Formation includes intercalations of thin beds of coarse biocalcarenites, which are turbidity deposits composed of shallower-water benthic organisms. These beds occurr at a frequency of 1 to 1.5 meter interval in the sequence. These turbidites are comparable to the shallow-water biogenic turbidites present in the Neiba facies near Ennery (Figures 16, 17A), as previously mentioned.

The Jérémie Formation thus represents a deeper-water equivalent of the Neiba Formation, which in turn is deeper than the Plaisance type of facies, as previously discussed.

LA CRETE FORMATION: Butterlin, 1954, p.63; 181. Named after Morne La Crête, between Gonaives and Gros Mornes in the Northwestern Peninsula (Figure 12).

Type locality: Road Gonaives - Gros Mornes, at an altitude of 235 meters on La Crête Hill.

The La Crête Formation consists of hard, sandy yellow limestones, often including coralline fragments, and intercalated with argillaceous limestones, thinnly bedded gray and brown marls, and sandstones which include volcanic and limestone fragments. (Figure 11).

North of the type locality the formation includes a volcanogenic basal conglomerate unconformably overlying lower Oligocene limestones (Butterlin, 1960). It is also reported to be uncorformably overlain by Miocene and Pleistocene series. Its estimated thickness is about 500 meters.

Butterlin (1954, 1960) assigned an Oligo-Miocene age to the La Crête Formation on the basis of the occurrence of the following benthonic foraminiferal taxa: Amphistegina sp. aff. A. Lessoni, Gypsina pilaris, Miogypsina antillea, Lepidocyclina canellei, and Madreporaria such as Heliastrea canalis, Placoenia tampaensis var silecensis, and Siderastrea conferta.

I studied numerous samples from outcrops of this lithofacies on the road Gonaives - Gros Mornes and found that they consistently yielded planktonic foraminiferal fauna indicative of the Early Miocene Globorotalia kugleri Zone and younger. Thus this formation may in fact be of Miocene age only.

Facies of the La Crete Formation are found in the Northwestern Peninsula of Haiti.

NEOGENE

ARTIBONITE GROUP

Woodring (1922, p.6) introduced the term Artibonite Group to include most of the Formations of the Plateau Central previously studied by Jones (1918), and to which he added the Madame Joie Formation. In the present summary I include all the Neogene Formations of the Plateau Central, which are also found in the Artibonite basin areas, under the heading of Artibonite Group. (Figure 11).

ARC FORMATION: Kirk, 1940, in Van den Bold, 1974, p.536. Arc is an acronym for Atlantic Refining Company.

Type locality: Not designated by original author. Van den Bold (1974, 1981) used a lithologic sequence along the Agoiadome River in northeastern Plateau Central as the type section (Figure 12). His choice is based on earlier work of ARCO geologists.

The Arc Formation consist of a lower part of basal conglomerate and bedded limestone with shale partings; a middle part of sandy marl with flaggy limestone layers (only partly exposed in the Agoiadome section); and an upper part of coralline limestone, conglomerate and interbedded marl (Van den Bold, 1974, 1981) (Figure 11). According to Van den Bold 1974, the lower part of the formation probably overlies the Bassin Zim limestones, which are in turn reported to unconformably overlie medial Eocene limestones (Butterlin, 1960). The upper part of the Arc Formation is overlain by the Las Cahobas Formation (see following paragraphs). The total thickness of the formation, excluding the Bassin Zim limestones, is approximately 1300 meters: lower part approximately 200 meters; medial part 800 meters; upper part 300 meters (Van den Bold, 1981). The thickness of the Bassin Zim limestones is undetermined.